SPEED AND ACCELERATION MONITORING DEVICE USING VISIBLE LASER BEAMS

BACKGROUND OF THE INVENTION

Motor vehicles are one of the major contributors to air pollution both in the United States and abroad. Thus, it is desirable to measure exhaust emissions from automobiles under actual operating conditions in order to identify excessively polluting vehicles and either have them repaired or have them removed from the road. Apparatus for detecting and measuring relative concentrations of pollutants such as HC, CO, and CO2 in the exhaust emissions from automobiles under operating conditions have been developed. Examples of such apparatus are shown in U.S. Pat. Nos. 5,343,043 (Johnson) and 5,210,702 (Bishop, et al.), which are incorporated by reference herein.

In order to properly analyze the exhaust emissions data obtained, the speed and/or acceleration of the vehicle at the time the exhaust emissions information was obtained is very useful. More specifically, the emissions test results can be influenced by the specific mode of operation, for example, acceleration or decceleration, of the vehicle under the test. Determining the mode of operation must be performed in a very short distance of travel, so as to capture instantaneously the specific accelerator position. This in turn supplies information about fuel enrichment and fuel deprivation of the engine at the specific time of the emissions test.

Devices have been developed in the past to determine the speed of vehicles. One such device is the radar detector used by law enforcement agencies. Although such radar devices are quite useful, radar waves can reflect off several points of the same vehicle, resulting in obtaining different speeds for the same vehicle traveling at a constant velocity. Another device for determining the speed of motor vehicles is the mechanical switch. Mechanical switches, however, have a great variance in response time. Also, cumbersome methods are needed, such as taping the sensors down to the highway, to keep the switches at a fixed length apart. Still another device is the use of modulated infrared laser beams. The modulated infrared laser beam has a set time for the beam to be on and off. This time translates into time steps that can cause error in the detection of the laser beam and, thus, accurate and reliable results may not be obtained.

BRIEF SUMMARY OF THE INVENTION

In view of the foregoing, it is one object of the present invention to provide an improved apparatus and method for monitoring the speed and acceleration of a motor vehicle, especially over a short distance.

It is another object of the present invention to provide an apparatus and method for accurately and reliably obtaining the speed and acceleration of a motor vehicle using visible laser beams positioned low to the ground.

Another object of the present invention is to detect at least the front wheel and the rear wheel of a motor vehicle using visible, non-modulated laser beams to obtain the speed and acceleration of the motor vehicle.

It is yet another object of the present invention to use the speed and acceleration data in combination with data on pollutants obtained from motor vehicles in-use to analyze exhaust emissions data.

The invention consists of certain novel features and a combination of parts hereinafter fully described, illustrated in the accompanying drawings, and particularly pointed out in the appended claims, it being understood that various

chan[illegible] the details may be made without departing [illegible] the spirit, or sacrificing any of the advantages, of the present invention.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

For the purpose of facilitating an understanding of the invention there is illustrated in the accompanying drawings a preferred embodiment thereof, from an inspection of which, when considered in connection with the following description, the invention, its construction and operation, and many of its advantages should be readily understood and appreciated.

FIG. 1 is a schematic diagram of an embodiment of the present invention shown in use across a roadway;

FIG. 2 is a block diagram of an embodiment of the present invention;

FIG. 3 is an pictorial view of a portion of the present invention;

FIG. 4 is a block diagram showing the calculator unit of FIG. 2 in more detail; and

FIG. 5 is a vehicle emission testing unit known in the prior art and useful with the embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 illustrates one embodiment of the present invention in use along a roadway 10. A motor vehicle 11 having at least a front wheel 12 and a rear wheel 13 is traveling along a roadway 10. The present invention includes a first radiation source 14, a second radiation source 15, a first detector 16 and a second detector 17. A visible entrance laser beam 18 is emitted from the first radiation source 14 and received by the first detector 16. An visible exit laser beam 19 is emitted from the second radiation source 15 and received by the second detector 17. The entrance laser beam 18 and the exit laser beam 19 are separated by a known fixed distance, d. Although the distance, d, can be any length, in a preferred embodiment, the distance, d, is small, preferably 70 inches.

In a preferred embodiment, the entrance laser beam 18 and the exit laser beam 19 are visible, that is, the laser beams are in the visible light spectrum. Visible laser beams 18, 19, allow the radiation sources 14, 15, to be accurately and precisely aligned with the respective detectors 16, 17, without requiring additional alignment beams, and to be positioned accurately close to the ground to allow only the wheels 12, 13, to be detected. The use of visible laser beams 18, 19, allow the fixed distance, d, between the entrance laser beam 18 and exit laser beam 19 to be precisely set without requiring additional alignment equipment.

The visible laser beams 18, 19, are not modulated and are at a low power level. The use of unmodulated visible laser beams 18, 19, is radically different from the normal infrared lasers or other modulated light sources which spread out over a wide area with low specific area radiation intensity. With the sensors presently known for use, the modulation and beam width can cause inaccuracies that are not tolerable, especially for obtaining the speed, S, and acceleration, A, of a motor vehicle 11 over a short distance, such as 70 inches in the described embodiment.

The detectors 16, 17, can be photo transistors with a 1.5" lens, not shown, and with a bandpass filter of the proper wavelength. The lens allows for some amount of mechanical movement of the detectors 16, 17, without resulting in a

false detection of signals. In addition, the detectors 16, 17, may be operated in a saturated mode, which allow them to reject mechanical and electrical noise.

In one embodiment, in order to measure the speed, S, at which a vehicle such as the motor vehicle 11 is traveling, the time period for the motor vehicle 11 to break the entrance laser beam 18 and then break the exit laser beam 19 over a fixed distance, d, is measured in an analyzer 20 based on the known distance d and the outputs of the detectors 16, 17. In the following description, the time when the motor vehicle 11 enters the path of any of the laser beams 18, 19, will be referred to as a "break", and the time when the motor vehicle 11 leaves the path of any of the respective laser beams 18, 19, and the laser beam is re-established, it will be called a "make." The acceleration of the motor vehicle 11 can be calculated in the analyzer 20 by using the rate of change of the speed detected using the front and rear wheels 12, 13, and the two detectors 16, 17.

As shown in the block diagram of FIG. 2, the analyzer 20 of the present invention includes a timer 30, such as a counter and a clock for measuring time. There are already known various kinds of timers 30 for measuring time, so that it need not be described in detail herein. The timer 30 starts timing the instant the front wheel of the motor vehicle 11 breaks the entrance laser beam 18. The analyzer 20 includes a determining circuit 40 for producing a pulse when the motor vehicle 11 breaks and makes each of the entrance laser beam 18 and the exit laser beam 19. For example, the determining circuit 40 may include a circuit, mechanism and/or algorithm for detecting the presence and absence of the visible laser beam using the respective outputs from the detectors 16, 17. The determining circuit 40 may comprise flip-flops or one-shots that are triggered by changes in the signal levels of the outputs from the respective detectors 16, 17 to indicate the respective break and make of the entrance laser beam 18 and the exit laser beam 19

As shown in FIG. 2, the analyzer 20 also includes a storage circuit or memory 50 for recording the elapsed time each event occurs as timed by the timer 30 that is triggered by the output of the determining circuit 40. For example, the recorder 50 may store the times in the random access memory of a computer forming part of the analyzer 20. The times for the events that the recorder 50 records include the time when the front wheel 13 of the motor vehicle 11 breaks the entrance beam 18, the time when the entrance laser beam 18 is made or re-established, the time when the front wheel 12 of the motor vehicle 11 breaks the exit beam 19, the time when the exit beam 19 is re-established, the time when the rear wheel 13 of the motor vehicle 11 breaks the entrance laser beam 18, and the time when the entrance laser beam 18 is re-established, the time when the rear wheel 13 of the motor vehicle 11 breaks the exit laser beam 19, and the time when the exit laser beam 19 is re-established.

A calculating circuit 60, as illustrated in the block diagram of FIG. 2, is included in analyzer 20 of the present invention. The calculating circuit 60 calculates the speed and the rate of change of the speed using the fixed distance, d, and from each of the eight time values recorded by the recorder 50 for the various events. The calculating circuit 60 may include a computer, calculator, and/or any device, mechanism or algorithm for manipulating data and/or performing mathematical operations on the data, in order to calculate the speed, S, and acceleration, A, as will be described below. A suitable calculating circuit 60 is shown in FIG. 4. The values that the calculating circuit 60 calculates represents the speed, S, in miles per hour, or kilometers per hour, of the front and rear wheels and using the stored speed values, the calculating

circuit [illegible]lculates the acceleration, A, of the motor ve[illegible] 11 in [illegible] per hour per hour, feet per second per seco[illegible] centimeters per second per second, or whatever units are best used in the vehicle emissions testing unit 70, such as the one described in the above-identified U.S. Pat. No. 5,343,043 and as shown in FIG. 5 herein.

As illustrated in FIG. 3, the motor vehicle 11 has at least a front wheel 12 and a rear wheel 13. In a preferred embodiment, the first radiation source 14, the second radiation source 15, the first detector 16 and the second detector 17 are arranged to allow the front wheel 12 and the rear wheel 13 of a motor vehicle 11 to break and make each of the entrance laser beam 18 and exit laser beam 19. The visible laser beams 18, 19 are spaced apart by a distance d that is less then the wheelbase of the vehicle. Thus, in order to measure speed, S, and acceleration, A, of the motor vehicle 11 using the front wheel 12 and rear wheel 13, the time of the following events, which are determined by the determining circuit 40 and the timer 30 are recorded by the recorder 50:

t1a is the time when the front wheel breaks the entrance laser beam;

t1b is the time when the front wheel leaves the entrance laser beam;

t2a is the time when the front wheel breaks the exit laser beam;

t2b is the time when the front wheel leaves the exit laser beam;

t3a is the time when the rear wheel breaks the entrance laser beam;

t3b is the time when the rear wheel leaves the entrance laser beam;

t4a is the time when the rear wheel breaks the exit laser beam; and

t4b is the time when the rear wheel leaves the exit laser beam.

As shown in the block diagram in FIG. 2, the preferred embodiment includes a timer 30 for measuring time. The timer 30 starts counting upon the front wheel 12 of the motor vehicle 11 breaking the entrance laser beam 18.

In the preferred embodiment, the calculating circuit 60, as illustrated generally in the block diagram of FIG. 2 and shown more specifically in FIG. 4, calculates speed, S, and acceleration, A, from the fixed distance, d, and from each time for the various events recorded by the recorder 50. In a preferred embodiment, the calculating circuit 60 calculates the speed, S, as S=(Speeda+Speedb)/2 and the acceleration, A, as A=(Accela+Accelb)/2; wherein:

Speeda=(S2a+S1a)/2;

Speedb=(S2b+S1b)/2;

S1a=d/(t2a-t1a)*(3600/(5280*12));

S1b=d/(t2b-t1b)*(3600/(5280*12));

S2a=d/(t4a-t3a)*(3600/(5280*12));

S2b=d/(t4b-t3b)*(3600/(5280*12));

Accela=DeltaVa/DeltaTa;

Accelb=DeltaVb/DeltaTb;

Delta Va=S2a-S1a;

Delta Ta=((t3a-t1a)+(t4a-t2a))/2;

Delta Vb=S2b-S1b;

Delta Tb=((t3b-t1b)+(t4b-t2b))/2;

The constant 3600/(5280*12) converts units from inches per second to miles per hour.

In addition to reducing and/or eliminating the above-mentioned problems, the use of a radiation source and

detector arrangement, as shown in FIG. 3, to provide visible laser beams 18, 19, at a position, that is, height, above the roadway 10 so as to detect the wheels 12, 13, only, would also gather twice as much data as simply detecting the front portion of the motor vehicle, that could be used for verification against the first measurement of speed, S, and acceleration, A.

In operation, when a two axle motor vehicle 11 is driven along a roadway 10, the front wheel 12 breaks the visible entrance laser beam 18. The occurrence of this event as detected by detector 16 and indicated by a pulse from the determining circuit 40 starts the timer or counter 30. The recorder 50 records the time of this event as indicated by the timer 30. When the determining circuit 40 produces a pulse indicating that the entrance laser beam 18 is re-established, that is, make, the time of occurrence of this event as measured by the timer 30 is recorded by the recorder 50. When the determining circuit 40 indicates that the front wheel 12 breaks the exit laser beam 19, the time of this event as measured by the timer 30 is recorded by the recorder 50. When the determining circuit 40 indicates that the exit laser beam 19 is re-established, that is, make, the time of occurrence of this event as measured by the timer 30 is recorded by the recorder 50. When the determining circuit 40 indicates that the rear wheel 13 breaks the entrance laser beam 18 the recorder 30 records the time of occurrence of this event as measured by the timer 30. When the determining circuit 40 indicates that the entrance laser beam 18 is re-established, that is, make, the time of occurrence of this event as measured by the timer 30 is recorded by the recorder 50. When the determining circuit 40 indicates that the rear wheel 13 breaks the exit laser beam 19, the time of occurrence of this event as measured by the timer 30 is recorded by the recorder 50. When the determining circuit 40 indicates that the exit laser beam 19 is re-established, that is, make, the time of occurrence of this event as measured by the timer 30 is recorded by the recorder 50. Using these stored values and the fixed distance d the speed, S, and the acceleration, A, of the motor vehicle 11 is then calculated.

As shown in FIGS. 1 and 2, the present invention includes a vehicle emissions test unit 70 for obtaining exhaust emissions data such as the relative concentrations of HC, CO and CO_2 from motor vehicles 11. Conventional devices for obtaining exhaust emissions data are known in the art such as U.S. Pat. Nos. 5,343,043 (Johnson) and 5,210,702 (Bishop, et al.) and will not be described herein. The analyzer 20 may be a part of the vehicle emissions test unit 70 or can be a separate unit.

As shown in FIGS. 1 and 2, the present invention may include a read out device 80, such as a monitor or screen, a digital display or printer, to display information, such as speed and acceleration, of the motor vehicle 11.

The use of the present invention to obtain an accurate value for the speed, S, and acceleration, A, of a motor vehicle 11 which can be used in combination with vehicle emissions information obtained from the same motor vehicle 11, allows accurate and reliable information to be obtained regarding the motor vehicle 11 that is being driven along a roadway 10.

The events and data recorded in Table 1 below are indicative of a normal speed/acceleration test, and are only exemplary and should not be used to limit the scope of the invention as set forth herein.